Washington State
Department of Transportation

Measures, Markers and Mileposts

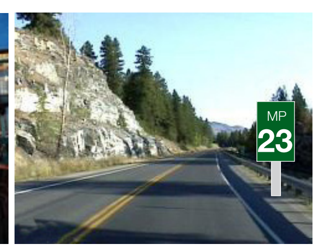
The Gray Notebook for the quarter ending
September 30, 2006

WSDOT's quarterly report to the Governor and the
Washington State Transportation Commission
on transportation programs and department management

Douglas B. MacDonald
Secretary of Transportation

Excerpt

WSDOT Congestion Report

Measuring Delay and Congestion: Annual Update

The major factor in congestion growth in Washington State is the growth in traffic demand against a static capacity. Too many people in the growing population want to travel on the same roads at the same time, resulting in the inability of the highway system to carry sufficient vehicles to meet demand. Non-recurring causes of capacity loss, such as vehicle accidents and breakdowns, are also major contributors to uneven traffic flow and reduced traffic throughput.

How Does WSDOT Measure Congestion?

WSDOT's mission is to move the largest number of *people* and largest amount of *freight* as efficiently as possible using current capacity. This is partly served by maximizing the number of *vehicles* that the highway can move through the system. Currently, maximum traffic throughput is achieved on a typical freeway segment in the Central Puget Sound region at about 51 mph (roughly 85% of the posted speed limits). When speeds fall below 70% of posted speed, or about 40 mph, the highway has lost efficiency to the level of significant congestion. Below 35 mph, the road operates in a severely congested manner.

WSDOT's Congestion Measurement Thresholds

Condition	Highway Speed Range	Description
Posted Speeds	52 mph or above (Posted Speed)	Highway is at less than maximum productivity because drivers are at greater than optimal spacing
Maximum Throughput	51 mph-41 mph (about 85%-70% of Posted Speed)	Highway is working at maximum productivity
Congestion	40 mph (below 70% of Posted Speed)	Highway is at less than maximum productivity because drivers are jammed at less than optimal spacing
Severe Congestion	35 mph or below (about 60% of posted speeds)	Highway is well below maximum productivity

Note: Maximum throughput figures are based on current technology and roadway geometrics. Improved vehicle and roadway technology could shift these thresholds upwards.

Report Summary

Critical Commute Routes: On 34 of the 35 commute routes analyzed, travel times increased at peak periods, speeds slowed, peaks became longer, and reliability of travel times worsened. All of these factors have resulted in reduced productivity of the freeway system, which means the system is less successful at meeting the need of people and freight to move around the region at the peak use hours.

Congestion Report Table of Contents

Evening Commutes: Data and analysis indicates evening commutes are generally worse – lasting longer, with lower speeds and less reliable travel times – than morning commutes, possibly because more non-commuting trips are also accessing the highways. Also, peak periods are getting longer. Statewide, total hours of delay have increased but commuters already suffering from congestion have seen even higher increases in delay.

Commute Corridors: For I-5, specifically north from Federal Way and south from Everett, data and analysis indicates generally corridor commuters continue to experience the longest peak period congestion. Meanwhile, in general, more people are using HOV lanes, providing more capacity for use of the general purpose lanes. Usage for all but one HOV lane has gone up.

Measures of Congestion

WSDOT uses several measures to track the effect that congestion has on state highways. For definitions of these measures, see the box on p. 55. Peak Travel Time and 95% Reliable Travel

WSDOT's Congestion Measurement Principles (since 2002):

- Use real-time measurements (rather than modeling) whenever possible.
- Measure congestion due to incidents as distinct from congestion due to inadequate capacity.
- Show whether reducing congestion from incidents will improve travel time reliability.
- Use plain English to describe congestion measures.
- Demonstrate both long-term and short-to-intermediate term results.
- Communicate about possible congestion fixes using an "apples to apples" comparison with the current situation (for example, if the trip takes 20 minutes today, how many minutes shorter will it be if we improve the interchanges?)

Measuring Delay and Congestion: Annual Update

Inventory and Definitions of WSDOT's Congestion Measurement Terms

WSDOT's Congestion Measures
Average Peak Travel Time. The average travel time on a route during the peak travel period.

The 95% Reliable Travel Time. An estimated travel time with 95% certainty. For example, if you travel during peak travel periods five days a week for a four-week period (20 weekdays), using the 95% reliable travel time, you will get to your destination on-time on 19 out of those 20 days.

Vehicle Throughput. A measure of the number of vehicles that can pass through a roadway segment during a given time period, typically measured for one hour.

Lost Throughput Productivity. Percentage of a highway's throughput lost due to traffic congestion.

Delay. When calculating relative delay to compare different routes in the state (for the 3-D map on p. 65), WSDOT uses the average total daily hours of delay per mile based on 85% of the posted speed. When calculating total delay, WSDOT uses annual total vehicle hours of delay.

Percent of days that the speed falls below 35 mph. Percent of Days with Severe Congestion.

Before and After Measures. Before and After analysis of performance of selected highway projects (case studies).

New Measures in This Edition
Duration of Congestion. This period is defined as the period in which average weekday speed on a highway fell below 70% of posted speeds.

Maximum Throughput Travel Time Index (MT^3I) Ratio of Peak Travel Time to Maximum Throughput Travel Time.

Other Noteworthy Terms
Maximum throughput or Maximum productivity. When the highway is carrying the largest number of vehicles possible. This occurs when vehicles are traveling at 70%-85% of the posted speed limit. For freeways, it is ~50 mph.

Induction Loop Detectors. Today's most common technology used to collect real-time data on traffic flow. Embedded in the pavement, these electronic devices measure vehicle count and how long the vehicle occupies the loop - i.e., traffic speed.

Reverse Commute Routes. Traditional commutes have flows toward large population centers (like Seattle) in the morning and away in the evening. The "reverse commute" is the flow running in the opposite direction.

Peak Time. The five-minute period with the highest average travel time.

Peak Travel Periods. The morning (6 a.m. to 9 a.m.) and evening (3 p.m. to 7 p.m.) commute periods.

Time are the measures that interest commuters the most. These measures show the impact that congestion has on travel time and reliability. Overall traffic volume and throughput, while not a concern to individual drivers, show the big picture of how the highway system is handling traffic.

WSDOT Expands Congestion Reporting
This year's report expands the number of corridors WSDOT reports on for congestion. Past reports have focused on the Central Puget Sound as the main feature; however, this report expands the 20 original commute routes to include 15 additional critical commute routes.

In the past two years, the agency has developed congestion data tracking systems in Spokane and Vancouver. (See the September 2005 *Gray Notebook*, p. 71). Spokane data is reported on p. 60; Vancouver data is still in process. Meanwhile, WSDOT is pilot-testing a new technology called Automated License Plate Recognition (ALPR) to gather congestion data on arterial roads (see p. 74). This will help WSDOT provide more accurate information to more highway travelers, as well as the ability to manage the system for more efficiency.

Maximizing the Existing System: WSDOT's Toolbox

WSDOT has multiple efforts in effect to help maximize the efficiency of the existing transportation system. This includes capacity improvements funded by the Nickel and Transportation Partnership Fund projects to fix bottlenecks and chokepoints that currently disrupt traffic flow and cause congestion.

There are also multiple efforts underway to manage the current system as efficiently as possible. These efforts include High Occupancy Vehicle (HOV) lanes (see p. 68), Intelligent Transportation Systems and Transportation Management Centers (see June 2006 *Gray Notebook*, pp. 59-61), and the future High-Occupancy Toll (HOT) lanes pilot project (see September 2005 *Gray Notebook*, p. 80). WSDOT's Incident Response trucks rove major corridors constantly during high-peak traffic times, clearing traffic incidents as quickly as possible (see pp. 75-77). Finally, WSDOT manages several programs to offer commuters alternatives to driving alone as a demand reduction strategy (see pp. 78-81 for more details).

WSDOT is providing an expanded congestion report on its website. To view that, see http://www.wsdot.wa.gov/accountability/congestion/.

Measuring Delay and Congestion: Annual Update

Travel Time Analysis

MORNING: Key Commute Routes: Changes in Travel Time Performance, 2003 to 2005

Route	Route Description	Peak time	Length (Miles)	Travel Time (in min.) At Posted Speeds	Average Peak Travel Time, Based on Peak Time (in minutes) 2003	2005	Change (%)	95% Reliable Travel Time (in minutes) 2003	2005	Change (%)	Ratio of Peak Travel Time to Maximum Through-put Travel Time MT³I 2003	2005	Traffic Volume Peak Hour Change (%)	Duration of Peak Period (hours and minutes that average speed falls below 70% of posted speeds)[1] 2003	2005	change (in minutes)
To Seattle																
I-5	Everett to Seattle	7:30 AM	23.7	24	47	48	2%	70	68	-3%	1.7	1.7	-1%	2:30	2:35	5
I-5	Federal Way to Seattle	7:40 AM	21.8	22	40	44	10%	54	59	9%	1.6	1.7	-1%	2:30	2:45	15
I-90/I-5	Issaquah to Seattle	8:10 AM	15.5	15	23	26	13%	32	38	19%	1.2	1.3	3%	0:10	1:10	60
SR 520/I-5	Redmond to Seattle	8:40 AM	14.8	16	22	24	9%	29	33	14%	1.3	1.4	0%	0:20	1:00	40
I-5	SeaTac to Seattle	7:40 AM	12.9	13	23	25	9%	29	38	31%	1.5	1.6	-1%	2:25	3:15	50
I-405/I-90/I-5	Bellevue to Seattle	8:40 AM	10.7	11	15	16	7%	23	25	9%	1.2	1.3	1%	*	0:20	*
I-405/SR 520/I-5	Bellevue to Seattle	8:40 AM	10.5	11	18	19	6%	24	28	17%	1.4	1.4	-3%	1:15	1:30	15
To Bellevue																
I-5/I-405	Everett to Bellevue	7:25 AM	23.4	23	n/a	52	n/a	n/a	80	n/a	n/a	1.9	-1%	n/a	2:35	n/a
I-405	Bothell to Bellevue	7:30 AM	16.0	16	35	42	20%	61	66	8%	1.9	2.2	-1%	2:25	2:40	15
1-405	Tukwila to Bellevue	7:35 AM	13.5	13	31	39	26%	42	55	31%	2.0	2.5	4%	3:25	3:45	20
I-5/I-90/I-405	Seattle to Bellevue	7:50 AM	10.6	11	16	17	6%	20	26	30%	1.3	1.4	-2%	0:15	1:20	65
I-5/SR 520/ I-405	Seattle to Bellevue	7:50 AM	10.1	11	18	23	28%	26	35	35%	1.4	1.8	-2%	2:05	2:40	35
I-90/I-405	Issaquah to Bellevue	7:45 AM	9.5	9	17	19	12%	24	26	8%	1.5	1.7	3%	1:25	2:05	40
SR 520/I-405	Redmond to Bellevue	9:00 AM	7.1	8	10	9	-10%	12	12	0%	1.1	1.0	1%	*	*	*
To Other Locations																
I-5/SR 520	Seattle to Redmond	7:50 AM	14.7	16	24	29	21%	31	40	29%	1.3	1.6	-1%	1:35	2:20	45
SR 167	Auburn to Renton	7:40 AM	9.8	10	16	17	6%	24	26	8%	1.4	1.5	-2%	1:10	2:35	85
I-5/I-90	Seattle to Issaquah	7:45 AM	15.5	16	19	21	11%	23	26	13%	1.0	1.2	5%	*	n/a	*

Overall MT³I Ratio (average)

morning commutes	1.25	1.44

Source: WSDOT Traffic Operations and Washington State Transportation Center (TRAC) at the University of Washington
Note: An asterisk (*) indicates that speeds did not fall below 70% of posted speed on a route; and n/a means that no information is available for a route.
[1]SR 520 contains a four-mile stretch that has a posted speed limit of 50mph. In that location, duration is measured as beginning at 84% of the posted speed, which is equal to 70% of 60 mph.

WSDOT tracks performance data for 35 important commutes in the Central Puget Sound and two in Spokane. WSDOT reports on Average Travel Time, 95% Reliable Travel Time, traffic volume, the duration of peak period congestion, and the percent of weekdays when average travel speeds fell below 35 mph (see stamp graphs on pp. 63-64). These routes were tracked for changes in traffic conditions from 2003 to 2005. (Note: two commutes are new in 2005 and have no 2003 comparison data).

Overall, congestion conditions worsened for thirty-three commute routes. On one route, *Redmond to Bellevue, SR 520 morning commute*, conditions improved (see discussion on page 59).

Evening Commutes are Longer than Morning

On the 35 commute routes, morning commutes are generally shorter than evening commutes. Evening commutes tend to spread longer; more people are traveling for purposes other than commuting in the evening. By time of day, the magnitude of deterioration for morning peak commutes was less than that

Travel Time Analysis, continued

EVENING: Key Commute Routes: Changes in Travel Time Performance, 2003 to 2005

Route	Route Description	Peak time	Length (Miles)	Travel Time (in minutes) At Posted Speeds	Average Peak Travel Time (in minutes) 2003	2005	Change (%)	95% Reliable Travel Time (in minutes) 2003	2005	Change (%)	Ratio of Peak Travel Time to Maximum Through-put Travel Time MT³I 2003	2005	Traffic Volume Peak Hour Change (%)	Duration of Peak Period (hours and minutes that average speed falls below 70% of posted speeds) 2003	2005	change (in minutes)
From Seattle																
I-5	Seattle to Everett	5:20 PM	23.7	24	42	46	10%	60	68	13%	1.5	1.7	-2%	3:05	3:30	25
I-5	Seattle to Federal Way	5:15 PM	22.1	22	34	37	9%	51	55	8%	1.3	1.4	-2%	1:40	2:05	25
I-5/I-90	Seattle to Issaquah	5:25 PM	15.7	16	22	24	9%	32	36	13%	1.2	1.3	5%	*	0:15	*
I-5/SR 520	Seattle to Redmond	5:25 PM	14.7	16	27	30	11%	37	43	16%	1.5	1.6	0%	2:05	3:15	70
I-5	Seattle to SeaTac	5:15 PM	12.9	13	18	19	6%	22	26	18%	1.2	1.3	-1%	*	*	*
I-5/I-90/I-405	Seattle to Bellevue	5:35 PM	10.6	11	17	18	6%	27	31	15%	1.4	1.4	2%	0:30	0:55	25
I-5/SR 520/I-405	Seattle to Bellevue	5:30 PM	10.1	11	18	21	17%	27	33	22%	1.4	1.6	0%	2:25	3:00	35
From Bellevue																
I-405/I-5	Bellevue to Everett	4:25 PM	23.4	23	n/a	43	n/a	n/a	60	n/a	n/a	1.6	-1%	n/a	3:30	n/a
I-405	Bellevue to Bothell	5:10 PM	16.0	16	28	31	11%	38	44	16%	1.5	1.6	-1%	2:35	3:20	45
I-405	Bellevue to Tukwila	5:20 PM	13.5	13	25	32	28%	31	44	42%	1.6	2.0	0%	4:05	5:35	90
I-405/I-90/I-5	Bellevue to Seattle	5:30 PM	10.7	11	21	26	24%	34	41	21%	1.7	2.1	1%	2:40	3:15	35
I-405/SR 520/I-5	Bellevue to Seattle	5:35 PM	10.5	11	22	28	27%	28	37	32%	1.8	2.3	0%	4:10	4:50	40
I-405/I-90	Bellevue to Issaquah	5:15 PM	9.3	9	15	18	20%	19	23	21%	1.4	1.6	7%	1:55	3:25	90
I-405/SR 520	Bellevue to Redmond	5:15 PM	6.8	8	12	14	17%	17	22	29%	1.3	1.6	-2%	1:45	3:30	105
From Other Locations																
I-5	Everett to Seattle	4:40 PM	23.7	24	36	40	11%	51	56	10%	1.3	1.4	0%	0:30	2:50	140
I-90/I-5	Issaquah to Seattle	5:35 PM	15.5	15	22	26	18%	33	45	36%	1.2	1.4	4%	*	0:45	*
SR 520/I-5	Redmond to Seattle	5:35 PM	14.8	16	29	37	28%	41	61	49%	1.6	2.0	1%	3:10	3:55	45
SR 167	Renton to Auburn	5:25 PM	9.8	10	16	18	13%	27	33	22%	1.4	1.6	-2%	2:50	3:05	15

Source: WSDOT Traffic Operations and Washington State Transportation Center (TRAC) at the University of Washington
Note: An asterisk (*) indicates that speeds did not fall below 70% of posted speed on a route; and n/a means that no information is available for a route.

Overall MT³I Ratio (average)

evening commutes	1.39	1.58

[1]SR 520 contains a four-mile stretch that has a posted speed limit of 50mph. In that location, duration is measured as beginning at 84% of the posted speed, which is equal to 70% of 60 mph.

of evening peak commutes. Even within the same commute, a morning commute to work appeared less congested than an evening commute home on many routes.

Bellevue-Based Worksite Commutes are Worst

Based on average speeds during peak hours and probability of having severe congestion (speeds of less than 35 mph), congestion intensity for Bellevue-bound morning routes was worse than the commutes to Seattle (except for *Redmond to Bellevue, SR 520 morning commute*, which will be discussed later). By the same token, evening commutes home from Bellevue to most destinations were worse than coming home from Seattle.

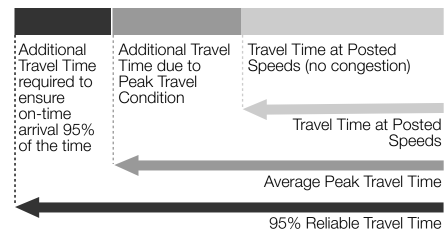
The worst two commutes were going home from Bellevue. The worst route was *Bellevue to Tukwila, I-405 evening commute,* with five hours and 35 minutes in congestion duration; for four hours and 10 minutes of that period, average speeds fell below

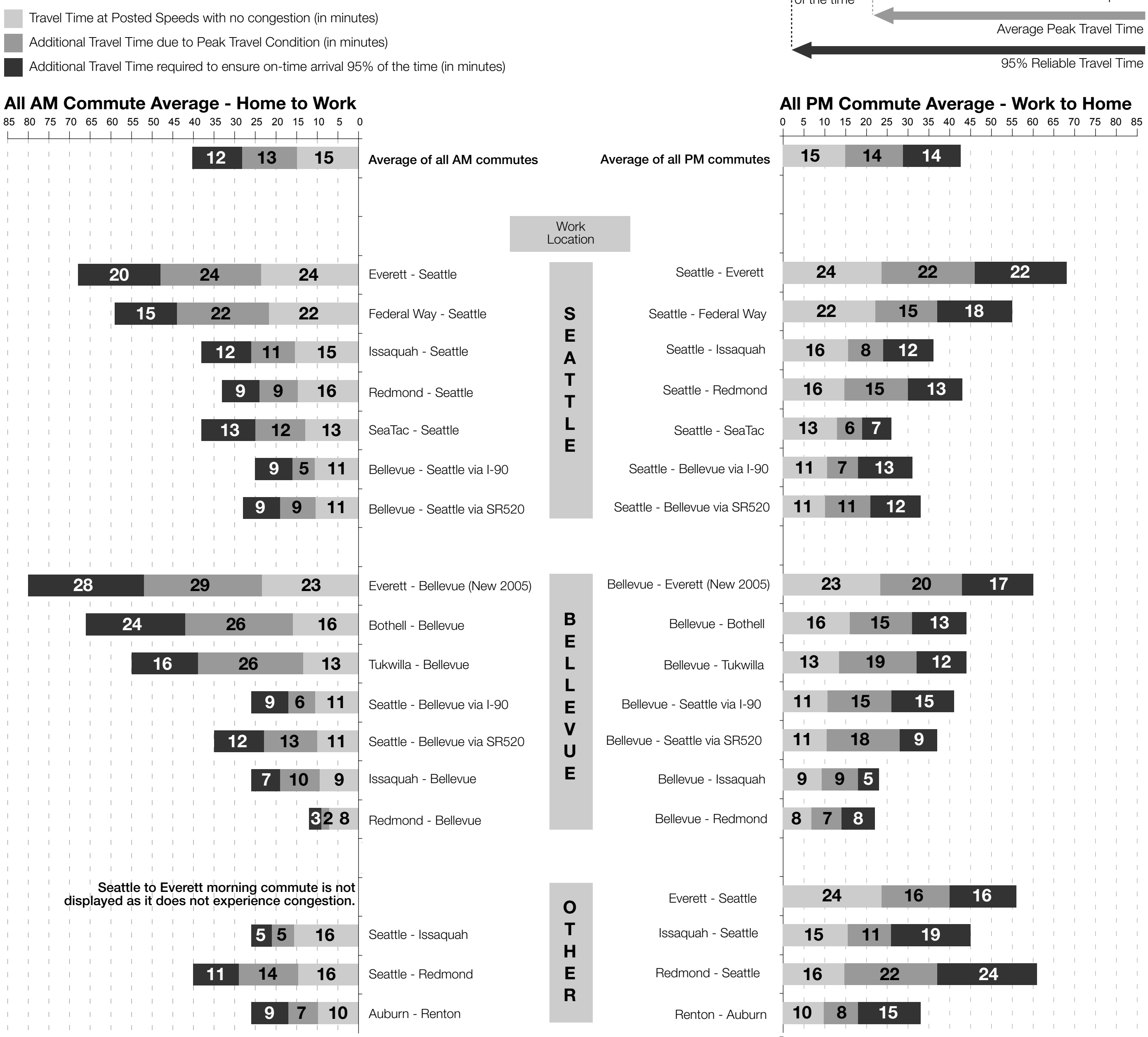
continued on p. 59

Travel Time Analysis, continued

Below is a graphical representation of the tables from pp. 56-57, showing three of the reliability performance indicators: travel time at posted speeds, average peak travel time, and 95% reliable travel time.

Travel Times at Posted Speeds, Peak Travel Times, and 95% Reliable Travel Time
Morning and Afternoon Commutes by Work Location
Central Puget Sound Area, 2005
Travel Time in Minutes





Travel Time Analysis, continued

35 mph (severe congestion). Since 2003, the Average Travel Time has increased by seven minutes and 95% Reliable Travel Time by 13 minutes—indicating that traffic conditions have become much less predictable for this route.

The second worst commute was a reverse commute, *Bellevue to Seattle, SR 520 evening commute*. Duration of congestion was four hours and 50 minutes, up 40 minutes from 2003. Another commute that shares the same route, *Redmond to Seattle, SR 520 evening commute*, turned out to be similarly bad, with a 45 minute increase in peak period duration to three hours and 55 minutes.

Morning Commutes to Seattle Worse on I-5 than on I-90 and SR 520

Traveling to Seattle in the morning was worse on I-5, both northbound and southbound, than traveling on I-90 or SR 520 across Lake Washington to Seattle. Although Average Travel Times increased for all routes to Seattle, additional time required due to congestion—mile per mile—was still less when traveling across Lake Washington than on I-5 from Federal Way, SeaTac, or Everett. For commute routes across Lake Washington, average speeds did not fall below 35 mph in 2005, while on I-5 routes, average speeds did go below 35 mph around peak times.

I-5 Commute to Seattle from Federal Way and SeaTac Worse than from Everett

On I-5 to Seattle, commutes from Federal Way and from SeaTac to Seattle were worse than from Everett to Seattle. The lengths of the commute routes from Federal Way to Seattle (22 miles) and from Everett to Seattle (24 miles) are approximately comparable. While duration of congestion was about the same from both Federal Way and from Everett to Seattle (two hours and 45 minutes from Federal Way and two hours and 35 minutes from Everett), the period of severe congestion (below 35 mph) was slightly longer from Federal Way (65 minutes) than from Everett (50 minutes).

I-90 Experiences Comparatively Little Congestion

The I-90 commute routes (Issaquah-Seattle and Bellevue-Seattle) show less congestion relative to other commutes. The only exception to this is *Bellevue to Seattle I-90 evening commute*. On the I-90 routes, although the duration of congestion increased from 2003 to 2005, the magnitude of congestion was better than other commutes across all of the measures: Average Travel Time, 95% Reliable Travel Time, percent of weekdays when average travel speeds fell below 35 mph, and duration of congestion.

Nevertheless, all routes through I-90 must be monitored closely for future onset of congestion since travel volume increased by the greatest margin as compared to other routes in 2005, both during peak hours and for the average daily total volume. The volume increase was greatest for the I-90 commutes to and from Issaquah (6% increase in total daily vehicle volume for Issaquah-Bellevue and 3-4% increase for Issaquah-Seattle). Peak hour volume increased 3%-7% for Issaquah-Seattle and Issaquah-Bellevue commutes. This indicates that more people were traveling on these routes in 2005 than in 2003.

One Commute Showing Improvement

There was only one commute route with improvement in congestion condition, *Redmond to Bellevue, SR 520 morning commute*, where Average Travel Time improved by one minute. This was the only commute route that showed improvement in average peak travel time from 2003 of all the commutes routes. This route may be heavily influenced by local business and commute pattern changes since the morning peak travel time is at 9:00 AM, much later than peak times for the other morning commutes. There may also be more local arterial roads available for alternative commutes or riding bikes to Redmond, since total daily traffic volume decreased by 2%.

Vehicle Volumes Increase Overall, but Drop for Peak Commuting Periods

Two different types of vehicle volume changes from 2003 to 2005 were investigated for each commute route: volume during peak hours and the total daily volume. The most important finding was the peak period vehicle volumes decreased slightly for most of the commutes with deteriorating conditions, while total daily vehicle volumes increased slightly over this two year period.

Comparison of 2003 and 2005 data show that on several freeways in the Central Puget Sound (such as I-5), while delay increased significantly, VMT decreased slightly. This is the first time that the data has shown delay and VMT moving in opposite directions.

This phenomenon is perhaps the result of two intertwined factors at work: increases in population and increases in the number of jobs leading to higher peak period demand and increased delay, while rising gas prices contributed to a decrease in discretionary, non-peak period trips. Since on most of the Central Puget Sound freeways, travel demands in the peak periods have already exceeded their capacities, increased demand in the peak resulted in longer delays but fewer vehicles could get through. Consequently, on a 24 hour basis, delay increased, while VMT decreased.

Travel Time Analysis, continued

A closer examination of I-5 data partially confirmed this hypothesis. The analysis showed that from 2003 to 2005, most of the VMT drop occurred during the off peak times, suggesting a reduction in discretionary travel. Other possible contributing factors include increased construction activities and higher incident rates. It is also likely that the slight drop in VMT on some of the highways was within loop detectors' margin of errors. This phenomenon will be closely watched in the next update to see if it is a temporary event or the start of a new trend.

Public Transportation Affects Volume

Another factor that WSDOT believes is influencing the decrease in vehicle volume during peak commute periods is the use of public transportation. A good example of increased use of public transportation was on the SR 520 commutes across Lake Washington. According to transit ridership data, there was a 21% (298,450 riders) increase for eastbound SR 520 to Bellevue and 19% (279,654 riders) increase for westbound SR 520 to Seattle in weekday ridership over the last decade.[1] On average, there was an increase of approximately 30,000 riders each year during the last 10-year period, many likely switching from their own vehicles to buses.

This effect is seen in this year's report as the decrease in vehicle volume over the SR 520 commutes from 2003 to 2005. The largest peak volume decrease of all commutes was *Bellevue to Seattle, SR 520 morning commute*, down 3%. The reverse commute for the same route, *Seattle to Bellevue, SR 520 morning commute* also had a 2% decrease in peak vehicle volume. Meanwhile, total daily vehicle volume decreased by 1% in the afternoon period on SR 520.

For more information on WSDOT's efforts to support commuter options, please see pp. 78-81.

Key Spokane Commute Routes: 2005 Travel Time Performance

Route	Route Description	Peak time	Length (Miles)	Travel Time (in minutes) At Posted Speeds	Average Peak Travel Time in minutes	95% Reliable Travel Time in minutes	Ratio of Peak Travel Time to Maximum Throughput Travel Time	vehicles per day	vehicles per day change (%)	Duration of Peak Period (hours and minutes that average speed falls below 70% of posted speeds) 2003	2005	change (in minutes)
I-90	Argonne Rd. to Division St.	7:50 AM	7.5	7	8	9	1.00	33,733	n/a	*	*	*
I-90	Division St. to Argonne Rd.	5:20 PM	7.5	7	8	11	1.03	36,934	n/a	*	*	*

Source: Spokane Regional Transportation Management Center (a partnership among WSDOT, the Cities of Spokane and Spokane Valley, Spokane County, the Spokane Regional Transportation Council and the Spokane Transit Authority)

Note: This data is gathered from the Performance Measurement System (PeMS), created by Berkeley Transportation Systems. It is a different system than the one used for gathering Puget Sound congestion data. Therefore, a direct comparison of data from the two regions is difficult. Furthermore, the road network in each of the two regions have different characteristics and different capacities, both of which are reflected in the data.
Note: An asterisk (*) indicates that speeds did not fall below 70% of posted speed on a route; and n/a means that no information is available for a route.

Spokane Peak Travel Analysis

Much of the congestion in the Spokane area is incident-related; the average travel times along the corridor are nearly what might be expected with free-flow speeds. Because the corridor is a relatively short segment (7.5 miles), even minor incidents can severely impact expected travel times as there is little opportunity to make up any incurred delay, as shown in the 95% reliable travel times.

[1] Based on unpublished data from King County Metro

Lost Throughput Productivity

What is Lost Throughput Productivity?

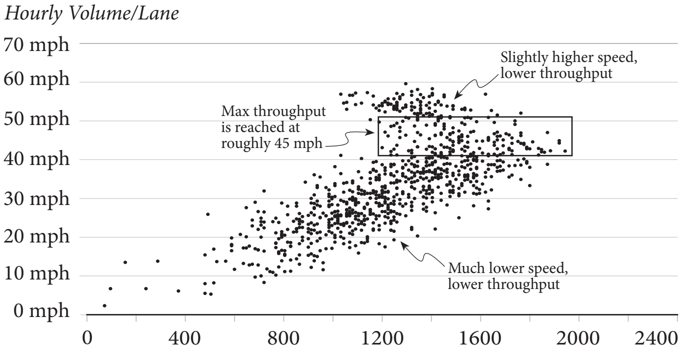
Congestion not only causes delay, it also causes lost productivity for the roadway system. That is, under congested conditions, even though the road is "full" of cars, they are moving so slowly that fewer vehicles actually pass any given point on the road. Typically, the maximum throughput of vehicles on a freeway, about 2,000 vehicles per lane per hour, occurs at speeds of 42-51 mph, or about 70%-85% of the posted speed. The goal is to manage the system to achieve maximum throughput/productivity.

As demand increases, congestion causes a drop in speeds. For a typical freeway, when speed drops to below 42 mph, or about 70% of 60 mph, the productivity of the freeway starts to decline. When congestion causes drivers to lower vehicle speeds to 30 mph, the throughput (volume of flow) on a freeway may fall from 2,000 vehicles per lane per hour to as low as 700.

Relating Speed and Volume

I-405 Northbound at 24th NE, 6-11 AM Weekdays in May 2001

Hourly Volume/Lane



According to the real-time data recorded on some of the most congested freeways in the Central Puget Sound, less than half the existing capacity is effectively used at a time when it is needed the most. When cars are stuck in congestion, the difference between the potential capacity of the roadway and the actual number of cars that the road is serving is called "lost productivity," "lost throughput," or "lost capacity". Whatever the term, congested freeways deliver far fewer benefits to citizens than if the roads could be kept flowing smoothly.

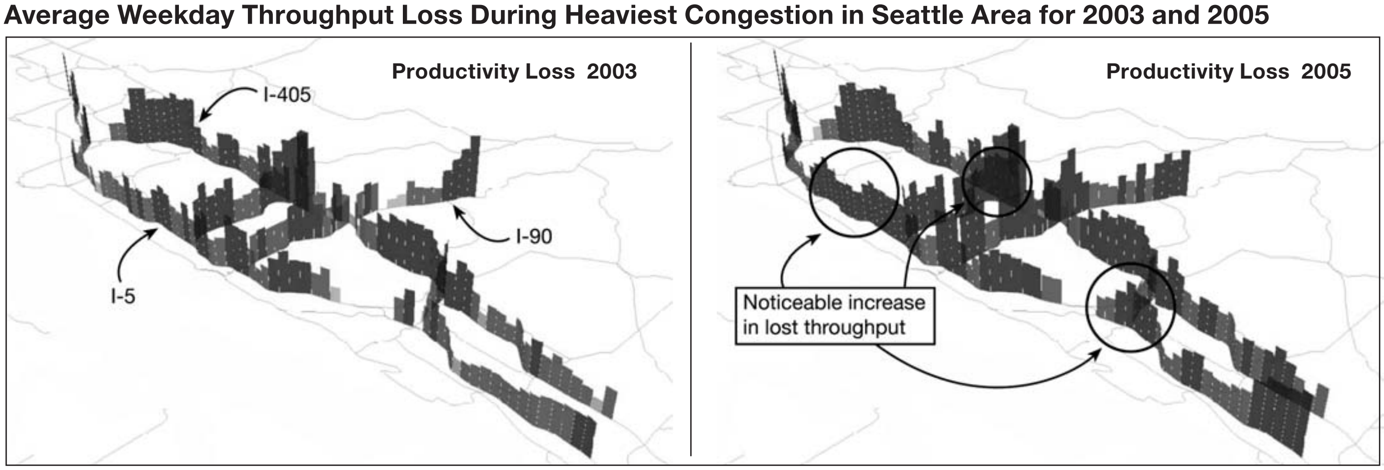
The maps at the bottom of the page provide an overview of average weekday loss of productivity on Central Puget Sound freeways during the most congested periods in 2003 and 2005. Data was gathered through loop detectors embedded in the roadway. The height of the bars in the graphs indicates percentage of throughput loss: the higher the bars, the higher the lost throughput. The highest spikes depicted on the map are located at I-5 at the I-90 interchange and through Downtown Seattle, I-405 in Renton, Downtown Bellevue and through Kirkland. The throughput loss these locations is as high as 50% or more during the most congested period.

As shown on the maps, from 2003 to 2005 there was an overall fall in freeway productivity. Most noticeable losses were on I-90 crossing Lake Washington, I-5 in north Seattle, and near Federal Way. In addition to increased overall traffic volume, the worsening throughput in Federal Way could be attributed to the construction impact of the direct HOV access ramps (see p. 72 for more information).

Analysis of Productivity Loss

The charts on page 62 compare throughput loss between 2003 and 2005 at selected locations on Puget Sound freeways where real-time data were available. The charts show the time period with the worst throughput loss. 100% indicates that the highway is working at maximum productivity. Most of the locations show minor decreases in productivity from 2003 to 2005, reflecting increased travel demand and congestion in the peak period. I-5 at I-90 and I-405 in Renton are among the most congested bottlenecks in the region; these two locations show slightly worse throughput loss than the other locations.

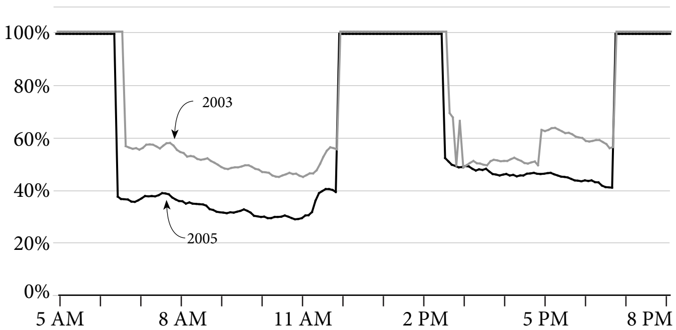
Average Weekday Throughput Loss During Heaviest Congestion in Seattle Area for 2003 and 2005



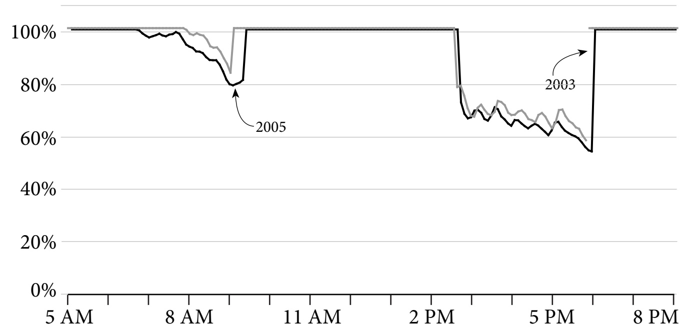
Measuring Delay and Congestion: Annual Update

Productivity Graphs (Lost Throughput)

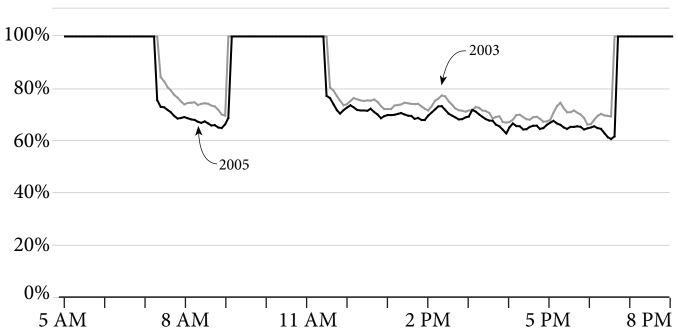
I-5 at I-90



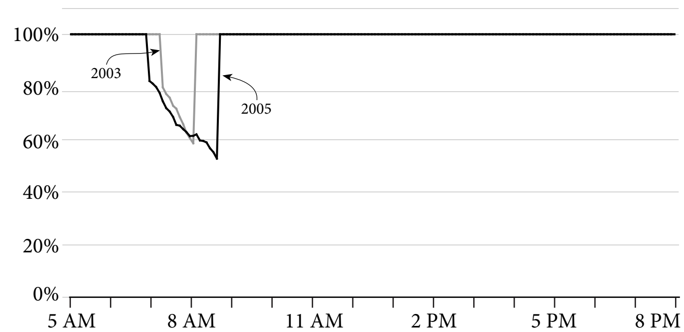
I-5 at S. 188th St. near Sea-Tac



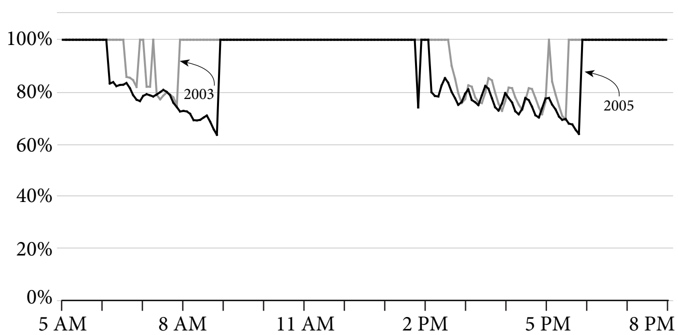
I-5 at NE 103rd St. near Northgate



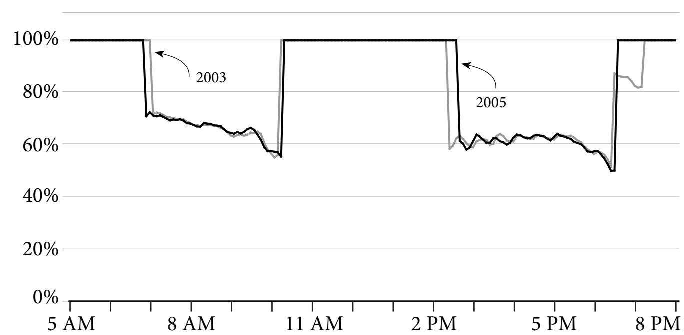
I-90 at SR 900 in Issaquah



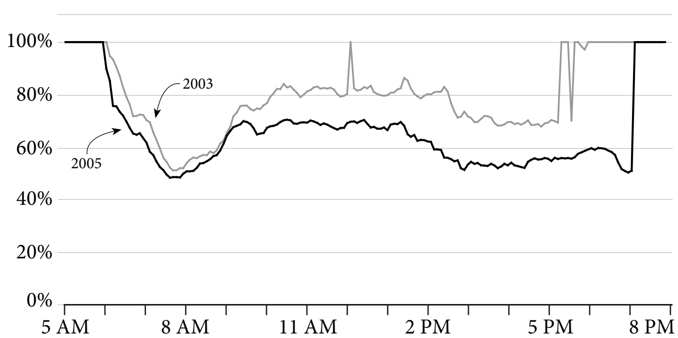
SR 167 at 84th Avenue SE



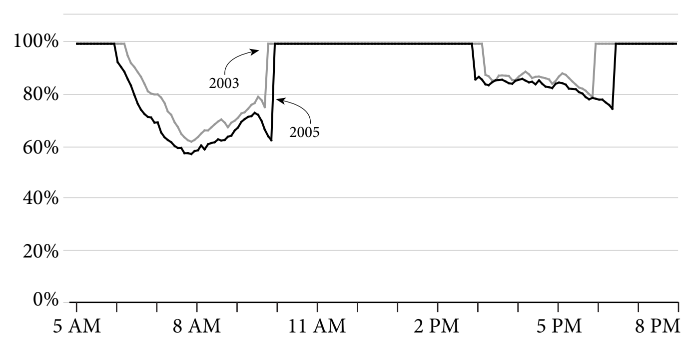
SR 520 Floating Bridge



I-405 at SR 169 in Renton



I-405 at NE 160th St in Kirkland



Measuring Delay and Congestion: Annual Update

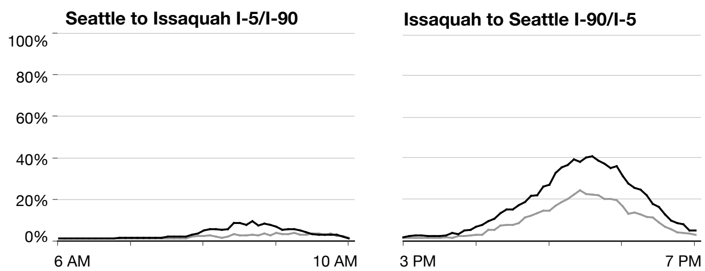
Percent of Days When Speeds Were Less Than 35 MPH

This page and the next contain "stamp graphs" showing severe congestion on the 35 Central Puget Sound routes tracked by WSDOT for performance reporting. These graphs, comparing 2003 and 2005 data, show the percent of days on each route when traffic speeds fell below 35 mph. For specific information on how to read stamp graphs, see the display on p. 66.

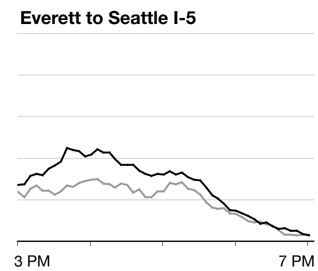
New Commutes for 2003-2005 Updates

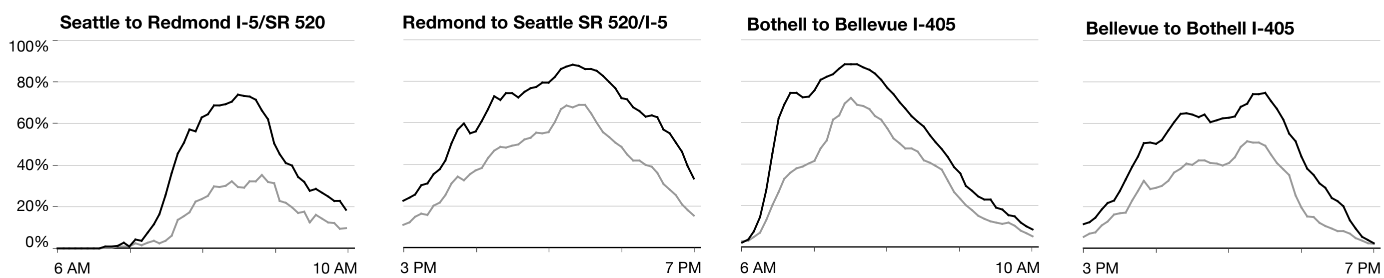
2003 2005

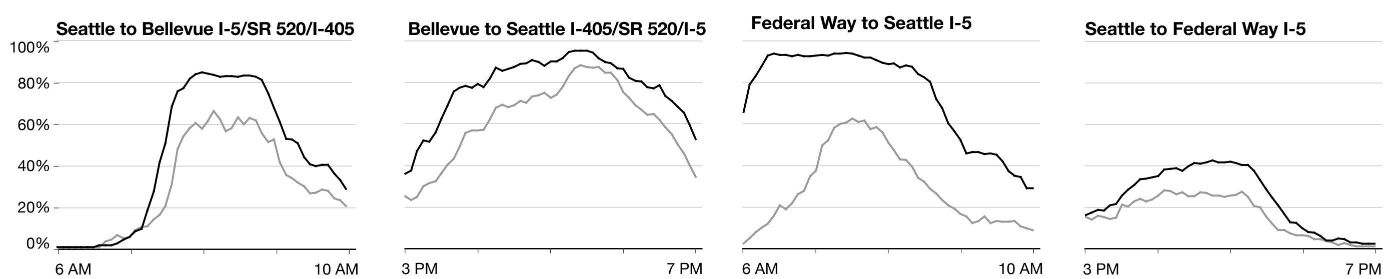
Morning	Afternoon	Morning	Afternoon

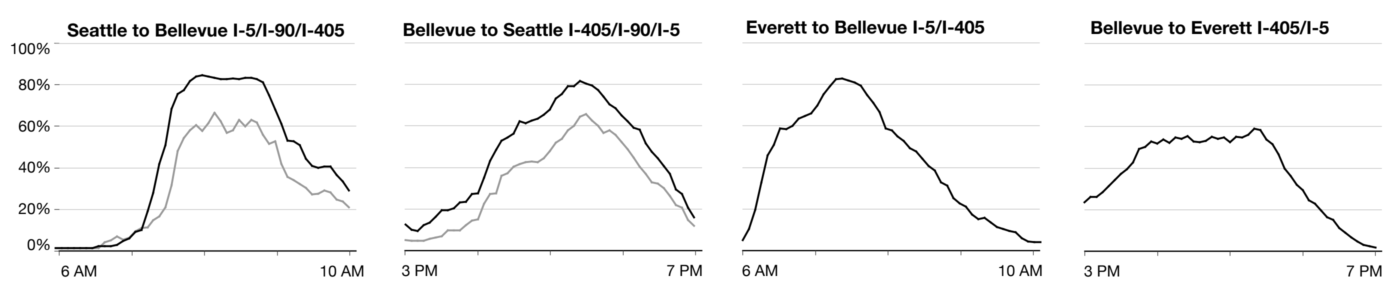


Everett to Seattle, I-5 is only tracked in the afternoon. The corresponding morning commute, Seattle to Everett, I-5, is not tracked.



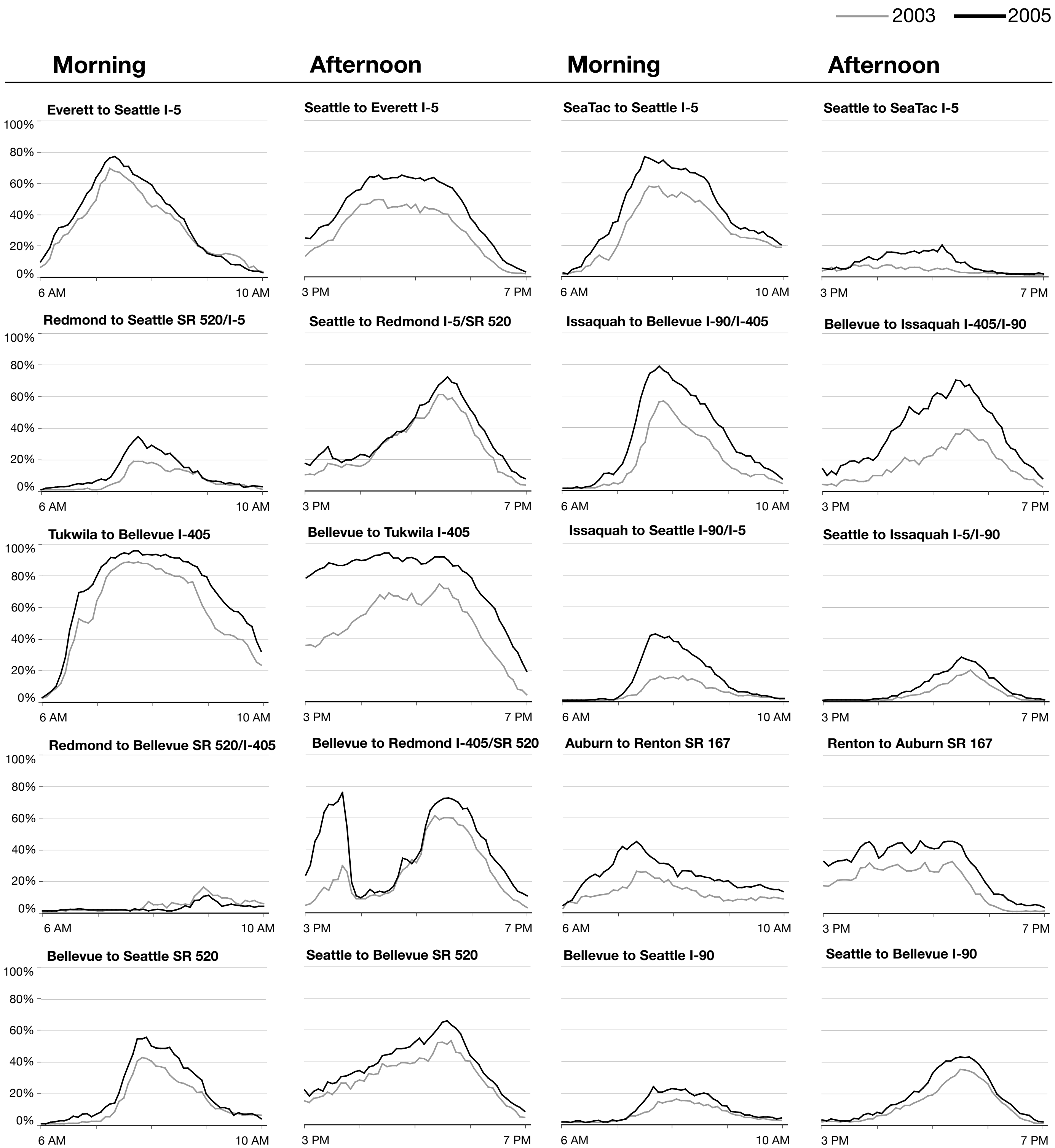






Measuring Delay and Congestion: Annual Update

Percent of Days When Speeds Were Less Than 35 MPH



Measuring Delay and Congestion: Annual Update

Measuring Travel Delay

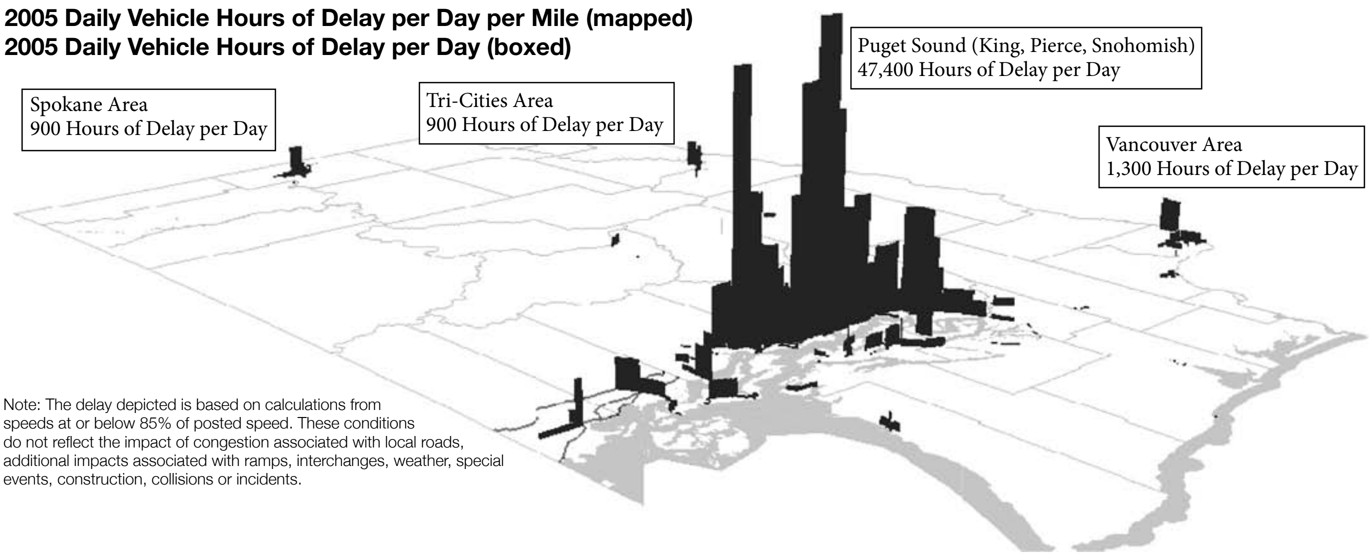
Congestion results in delay. The sum of vehicle delay across an average twenty-four hour day is in WSDOT's view the most basic and easily understood measure for describing congestion. It is the composite of the extent, severity and duration of congestion. Traditionally, delay has been calculated based on the difference between actual travel times and what the travel time would have been if traffic had been free flowing.

From a system efficiency standpoint, however, speeds at which maximum throughput is achieved are a better gauge for delay calculations. It makes more economic sense to measure the actual performance of the system against its maximum productivity than against the less productive (low throughput) condition of freeflow (posted) speeds.

Optimal flow speed (which produces maximum throughput) is not a static number. It varies from facility to facility and from segment to segment depending on conditions such as lane width, slope, shoulder width, pavement condition, traffic composition, presence or lack of a median barrier, etc. It should also be noted that, as cars are equipped with more sophisticated devices and become easier to maneuver, optimal flow speed (maximum throughput) should increase. Currently, optimal flow speed on a typical freeway segment in the Central Puget Sound region is about 50 mph (roughly 85% of the posted speed). For surface arterials, optimal flow speed is even more difficult to determine, as it is heavily influenced by conflicting traffic movements at intersections. Ideally, optimal flow speeds for each highway segment would be determined through comprehensive traffic studies and validated based on field surveys. Due to resources constraints and for simplicity, 85% of posted speed is used as a surrogate for the true optimal flow speed for the purpose of estimating delay.

The table below compares average weekday delay between 2003 and 2005 on all state highways, estimated fromtraffic counts collected on state highways. Statewide delay, relative to posted speed limits and relative to optimal flow speeds, increased by 11% and 21%, respectively. The higher percentage increase relative to optimal flow speeds indicates that many congested highways got even more congested from 2003 to 2005. This is clearly shown in the maps on p. 61.

2005 Daily Vehicle Hours of Delay per Day per Mile (mapped)
2005 Daily Vehicle Hours of Delay per Day (boxed)



Note: The delay depicted is based on calculations from speeds at or below 85% of posted speed. These conditions do not reflect the impact of congestion associated with local roads, additional impacts associated with ramps, interchanges, weather, special events, construction, collisions or incidents.

All State Highways: Average Weekday Delay Comparison (Daily and Annual) and Estimated Cost of Delay on State Highways (Annual), 2003 and 2005

	DAILY Average Vehicle Hours of Delay (Weekdays)			ANNUAL Average Weekday Hours of Vehicle Delay (in thousands)			ANNUAL Cost of Delay on State Highways (in Millions of 2005 dollars)		
Actual Travel Compared to	**2003**	**2005**	**Change**	**2003**	**2005**	**Change**	**2003**	**2005**	**Change**
Optimal Flow Speeds (Approx 51 mph)	82,200	99,400	21%	20,550	24,850	21%	$486	$598	23%
Posted Speeds	156,300	173,800	11%	39,075	43,450	11%	$920	$1,043	13%

Source: WSDOT Urban Planning Office

Measuring Delay and Congestion: Annual Update

Measuring Travel Delay, continued

From 2003 to 2005, delay on I-90, SR 167, and I-405 significantly increased. Overall, delay on the five freeways listed in the table on p. 67 increased by more than 20% relative to the posted speed limits and by over 50% relative to the optimal flow speed. .

The map on page 65 illustrates the relative delay distribution in Washington State. As it shows, delay is concentrated in the major urban areas, primarily the Central Puget Sound region.

Estimating the Cost of Delay

Congestion, or delay, imposes costs due to travelers' lost time, higher vehicle operating costs from wasted fuel, and other effects of stop-and-go driving. Truckers, shippers, and their customers also bear large costs from traffic delay. It is generally recognized that delay has a variety of direct and indirect impacts. These include increased travel time for personal travel, increased travel time for business travel, increased vehicle operating expense, shipper/recipient productivity loss, indirect (downstream) productivity loss, local income/economy loss of opportunities to attract new businesses, and increased vehicle pollution emissions due to stop and go conditions

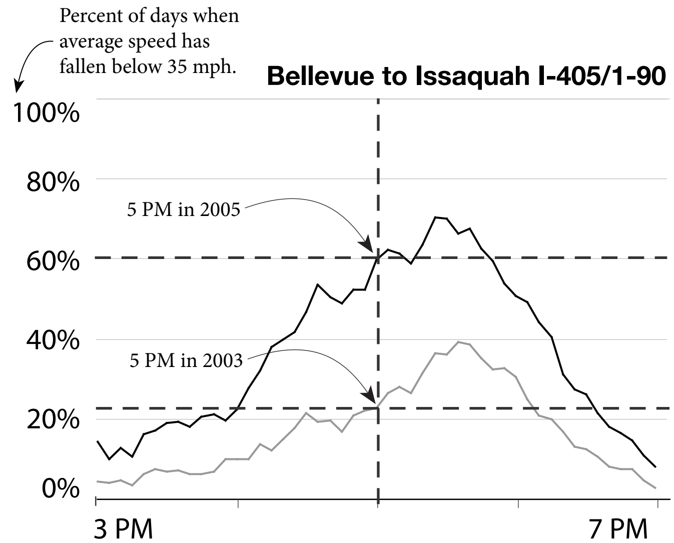
To put a dollar value on all of these impacts is a complicated task. A highly uncertain (even arbitrary) element in assessing the cost of delay are the assumptions used to express the value of time. The same amount of delay for different people, or even for the same people at different times and on different trips, may have a different economic value. For example, delay on a trip to day care to pick up kids could cost several dollars a minute after normal business hours, while the same length of delay on a trip to a store may have little or no economic consequence. For business trips, it is common to assume the value of time to be equivalent to average wage rates. But delay's secondary and long term effects are hard to gauge.

To make the task of quantifying the cost of delay possible, the cost of delay was calculated by applying value of time to the estimated hours of delay incurred to passenger and truck travel plus additional vehicle operating cost (see the September 2004 *Gray Notebook, p. 50)*. The value of time for passenger trips was assumed to be half of the average wage rate. Using the same approach with updated average wage rates, the annual cost of delay or congestion for 2003 and 2005 are estimated and shown in the table on page 65 (the preceding page).

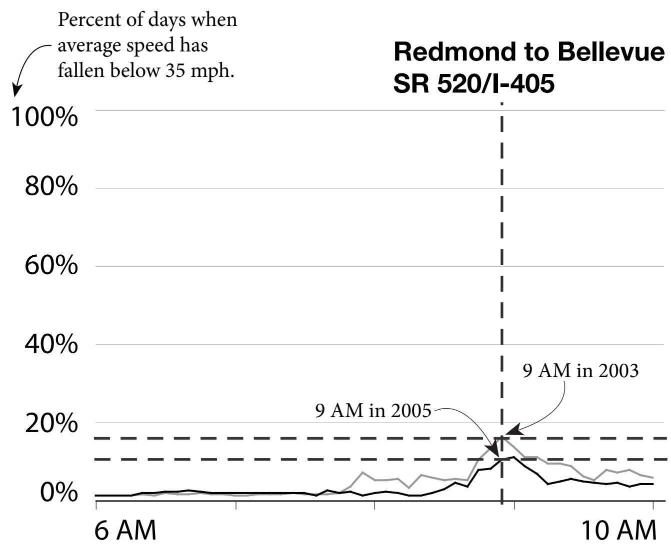
How to Read The Stamp Graphs on Pages 63-64

Percent of Days When Speeds Were Less Than 35 MPH - Twenty Puget Sound Commutes

How frequently (and when) did the average trip speed drop under 35 mph? Comparing 2005 to 2003. See pp. 63-64.



At 5:00 pm in 2003, you had about a 23% chance that traffic would be moving less than 35 mph. In 2005, the situation became worse (black line above the gray line); your chance that traffic would be moving slower than 35 mph was about 60% in 2005.



Near 9 am in 2003, you had about a 16% chance that traffic would be moving less than 35 mph. In 2005, the situation was better (black line below the gray line); your chance that traffic would be moving slower than 35 mph was about 11%.

Measuring Travel Delay, continued

Central Puget Sound Freeways: Average Weekday Delay Comparison 2003 and 2005

State Route	Center Lane Miles	Vehicle Hours of Delay per Day: Relative to 60 mph (posted speed limit)			Relative to approx. 50 mph (max throughput)			Vehicle Miles Traveled		
		2003	2005	Change	2003	2005	Change	2003	2005	Change
I-5	369	15,900	17,800	12%	6,800	9,000	32%	8,061,700	7,667,300	-5%
I-90	95	1,300	1,900	46%	250	700	180%	1,590,600	1,606,700	1%
SR 167	41	1,800	2,700	50%	400	1,000	150%	957,300	996,600	4%
I-405	152	9,400	13,200	40%	4,500	7,900	75%	3,660,300	3,647,200	-0.4%
SR 520	52	2,500	2,500	0%	1,300	1,500	15%	987,150	982,500	-0.5%
Total	709	30,900	38,100	23%	13,250	20,100	52%	15,257,050	14,900,300	-2%

Source: WSDOT Urban Planning Office

Note: Because both the lengths and widths of these corridors are different, it is not possible to use the delay numbers to rank the corridors.

Freeways Outside of the Central Puget Sound: Average Weekday Delay Comparison 2004 and 2005

State Route	Vicinity (and location)	Center Lane Miles	Vehicle Hours of Delay per Day: Relative to 60 mph (posted speed limit)			Relative to approx. 50 mph (max throughput)			Vehicle Miles Traveled		
			2004[1]	2005	Change	2004[1]	2005	Change	2004	2005	Change
I-5	Martin Way to Thurston/Pierce County Line (Lacey to Nisqually)	5.74	229.46	280.84	22%	17.29	30.83	78%	574,086	584,815	2%
I-205	SR 500 to NE 83rd Street (Vancouver)	2.15	150.36	200.27	33%	73.69	115.02	56%	148,023	152,434	3%
I-5	U.S. 101 to Martin Way (Olympia/ Lacey)	5.14	143.99	175.91	22%	12.91	21.45	66%	617,618	627,116	2%
I-205	Vancouver to SR 500 (Vancouver)	4.30	151.32	173.43	15%	59.33	62.80	6%	407,185	414,680	2%
I-90	Broadway Avenue to SR 27 (Spokane)	3.61	129.32	144.49	12%	54.35	63.52	17%	281,857	284,817	1%

Source: WSDOT Systems Analysis and Program Development Office

[1]2003 data is not available for routes outside of Puget Sound.
Note: Because both the lengths and widths of these corridors are different, it is not possible to use the delay numbers to rank the corridors.

Congestion Report Note: Data Limitations and Challenges

WSDOT's data collection faces some limitations. The data collectors used for these analyses do not provide universal coverage of the system. WSDOT primarily relies on loop detectors, which are embedded in pavement to collect traffic data. WSDOT is attempting to expand its data reach beyond loop-detector locations with new technology. The loop detectors also have limitations; they occasionally fail, and have different levels of accuracy in recording data. This can make it difficult to compare data from area to area or from year to year. The detectors are also affected by construction projects where lanes are shifted from their normal position or pavement is being rehabilitated. While adding additional loop detectors to the system improves precision and completeness for measurement purposes, it can also make year-to-year data comparisons more difficult. Finally, there is no single statewide data warehouse. Much of the data is managed regionally within the metropolitan areas around Seattle, Vancouver, and Spokane, each using a different data system. This makes it difficult for WSDOT to compare data from region to region. WSDOT is working to resolve this issue.

HOV Lane Performance

The Washington State freeway HOV system helps to maximize system productivity and provide reliable travel times and dependability for transit users and carpoolers. Approximately 200 miles of HOV lanes have been constructed in Central Puget Sound since 1970. The HOV lanes allow the highway system to operate more efficiently: they help reduce demand for vehicle throughput by offering an attractive alternative to drive-alone commuting, and multiple-occupancy vehicles help raise *person* throughput. WSDOT tracks two important aspects of HOV lane performance: travel time and reliability benefit to users, and volume of people being moved via HOV lanes as compared to the general purpose lanes.

For this report, WSDOT will compare 2005 data (the most recent data) with data from 2004.

HOV Lane Performance: Reliability

WSDOT and the Puget Sound Regional Council (PSRC) adopted a performance standard for freeway HOV lanes that states 90% of the time, the HOV lane should be able to maintain an average speed of 45 mph or greater during the peak hour of the peak period.[2]

Nine HOV Lanes Fail Reliability Standard Due to Saturated Volumes and Depressed Speeds

The 2005 performance results for the Puget Sound HOV lane system indicate significant portions of the freeway HOV lane system are operating over capacity; the reliability performance of several lanes is deteriorating under increasing vehicle usage during peak periods. Congestion in the HOV lanes has returned to the peak levels seen in 2000, when highway traffic peaked due to the economic boom. Six of the HOV lanes now have high enough traffic volumes that the corridors fail the HOV performance standard in the evening peak period, and four fail the standard in the morning period. In 2004, five corridors failed this standard in the evening peak period and three in the morning peak period. The table to the right illustrates which corridors and directions currently meet or fail the performance standard during the morning peak period and evening peak period.

Speed and reliability of the HOV lanes are continuously monitored and the results are published at http://depts.washington.edu/hov/.

HOV Lane Performance: Person Throughput

The sub-standard speed seen in the HOV lanes is due to the increase in their use. The WSDOT HOV lane monitoring program tracks volume in the HOV and general purpose lanes at 10 locations around the Central Puget Sound area that are representative of freeway use on all major freeway corridors in

Puget Sound Corridors Meeting HOV Lane Reliability Performance Goal

2004 and 2005, Based on Reliability Goal of the HOV Lane Maintaining a Speed of 45 mph for 90% of the Peak Hour[2]

Route	2004		2005	
	A.M.	P.M.	A.M.	P.M.
I-5, SR 522 to 112th St. (NB)	✓	Below	✓	Below
I-5, SR 526 to Northgate Way (SB)	Below	✓	Below	✓
I-405, I-5 Interchange (Tukwila) to NE 8th St. (NB)	Below[1]	✓	Below	✓
I-405, NE 8th St to I-5 Interchange (Tukwila) (SB)	✓	Below	✓	Below
I-90, S Rainier Ave to SR 900 (EB)	✓	✓	✓	✓
I-90, SR 900 to S Rainier Ave (WB)	✓	✓	✓	✓
SR 520, I-405 Interchange to West Lake Sammamish Parkway NE (EB)	✓	✓	✓	✓
SR 520, West Lake Sammamish Parkway NE to 84th Ave NE (WB)	✓	Below	✓	Below
SR 167, 15th St NW to I-405 Interchange (NB)	✓	✓	✓	✓
SR 167, I-405 Interchange to 15th St NW (SB)	✓	✓	✓	✓
I-5, S 320th St to I-90 Interchange (NB)	Below	✓	Below	✓
I-5, I-90 Interchange to S 320th St (SB)	✓	Below	✓	Below
I-405, NE 8th St to I-5 Interchange (Swamp Creek) (NB)	✓	Below[1]	✓	Below
I-405, I-5 Interchange (Swamp Creek) to NE 8th St (SB)	✓	✓	Below[1]	Below[1]

Source: University of Washington Transportation Research Center (TRAC)

Data Notes: TRAC analyzes performance data for all complete segments of HOV lanes that have a loop detector. In some cases, data is not analyzed for the very beginning and ends of the lanes because there are not detectors at the very beginnings and ends of the HOV lanes.
NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound
[1]Performance on these corridors was close to the standard; this corridor's failure was borderline.

[2]HOV reliability performance standards are based on the peak hour. Peak hour is the one-hour period during each peak period when average travel time is slowest.

HOV Lane Performance (continued)

the region. Vehicle and person volumes are measured in both directions for both HOV and general purpose lanes at each of these locations.

During the peak travel period in the direction of peak travel, all but one of the Puget Sound freeway HOV lanes gained vehicle volume between 2004 and 2005. Compared to 2004, volume in the HOV lanes at the 10 monitoring locations increased by an average of approximately 130 vehicles during the 3-hour morning peak period and approximately 120 vehicles in the 4-hour evening peak period. Traffic volumes measured in the general purpose lanes at those locations declined by an average of 165 vehicles in the morning peak period and 500 vehicles in the evening peak.

HOV Lanes are Effective at Moving People

HOV lanes are designed to move more people in fewer vehicles, by providing incentives that encourage people to share rides, either in carpools or by using transit. The HOV lane system generally succeeds in attracting large numbers of users, despite consisting of only one lane in each direction on each freeway route. At the 10 monitoring locations, the average HOV lane in the peak traffic direction carries almost 29% of the people on the freeway in the morning and almost 33% in the evening.[1]

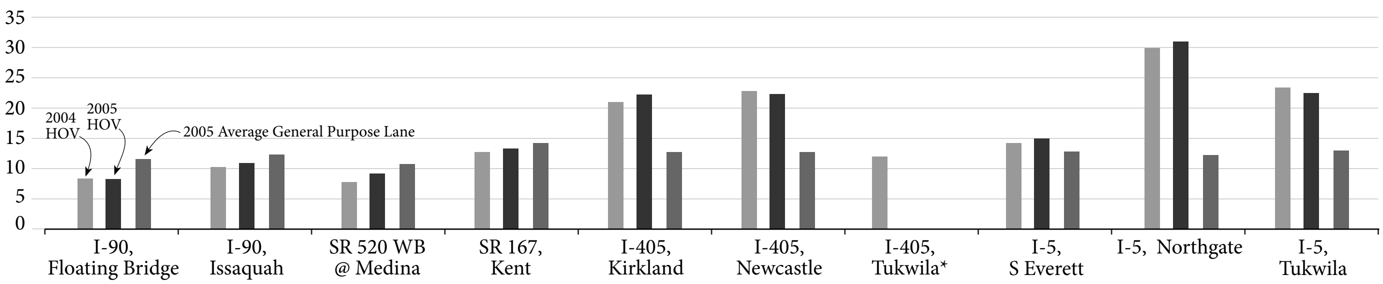
HOV lanes are not equally used throughout the region. The graph below shows how HOV lane use compares to general purpose lane use across the major corridors in the morning. HOV lane use is highest where general purpose lanes are very limited or where excellent transit service encourages use of the HOV lanes. I-5 near Northgate is an example of the person moving capability of comprehensive transit service operating in an HOV lane. In the morning peak period the southbound HOV lanes move over 13,700 people, or 43% of the people on that section of I-5, in only 21% of the vehicles. The HOV lane carries an average of 3.3 people in each vehicle, making it almost three times as effective at moving people as any of the adjacent general purpose lanes.

Not all HOV lanes carry such high percentages of freeway travelers. As noted in the September 2005 *Gray Notebook* report on HOV lanes (p. 66), I-90 and SR 167 both have HOV lanes with lower levels of use. In both cases, the time advantage provided by the HOV lane to travelers on these roadways is smaller than on I-405, I-5, or SR 520 westbound. As a result, less incentive exists to carpool or use transit. However, growing congestion on these roads is resulting in increasing HOV use. In particular, I-90 shows very large growth in HOV traffic. Between 2000 and 2005, traffic volumes on the HOV lane near Issaquah added nearly as many vehicles in the peak periods and peak directions as all of the general purpose lanes combined. While only 4,500 (23%) of the people on the facility at that location currently use the westbound HOV lanes in the morning peak period, that percentage will continue to grow in the future, particularly as more park and ride spaces and bus service are brought to the eastern end of the corridor, allowing more people to easily access convenient transit services.

Four HOV Lanes Are Not Meeting Person Throughput Expectations

On four corridors, HOV lane person throughput is not exceeding general purpose lane person throughput.

2004 HOV Lane and 2005 HOV Lane and General Purpose Lane Person Throughput Comparison
Total of A.M. and P.M. Peak Period Volumes
In Thousands



Note: Volumes are for peak period direction only.
Note: * This 2004 data has no corresponding 2005 data.
Source: University of Washington Transportation Research Center (TRAC)

[1]Person volume data is based on observation samples. At selected locations, observers standing on overpasses or alongside the road count the number of people in each car. Those samples, along with estimated bus ridership data and vanpool ridership data provided by transit agencies, are used to estimate average vehicle occupancies at those locations. The per-vehicle occupancies are then combined with vehicle counts (from the loop detector data) to get person volume estimates.

HOV Lane Performance (continued)

I-90 Floating Bridge HOV/Express Lanes. The two-lane HOV/ Express facility is underutilized because it has limited access points, including single-lane connections to I-90 mainline on either end. Also, the HOV lanes through Mercer Island are open to single-occupancy vehicles entering and exiting the highway. Person throughput was roughly steady from 2004 to 2005, but has grown in previous years.

I-90 Issaquah HOV Lanes. The HOV lanes here have lower volumes and lower transit usage throughout peak commute periods compared to some other locations in the network, but as noted above, HOV lane use is growing along the I-90 corridor. Population growth in Issaquah and other rapidly-developing Eastside areas is increasing all volumes along this commute route, and HOV facilities and transit service are expanding in this part of the Eastside.

SR 520 Westbound at Medina. This HOV shoulder lane has an operational constraint: the lane is restricted to three-person HOVs and transit for safety reasons. Despite this, the location compares very favorably to adjacent general purpose lanes during each peak commute hour and provides substantial travel time savings for regional transit bus service.

SR 167 in Kent. HOV lane use is modest for several reasons:
- There is limited bus service, in part due to *Sounder* train service to Seattle that serves the corridor.
- The HOV lane does not save a great deal of time for most travelers in the corridor because the worst congestion on SR 167 is south of the end of the HOV lane.
- A restriping project improved the flow of traffic on the general purpose lanes.

HOV User Survey Preliminary Conclusions

WSDOT distributed 30,000 surveys to freeway HOV lane users in January 2006; 5,700 people responded. The survey was intended to determine the extent to which HOV lanes encourage the choice of shared-ride modes, and to develop data concerning the use of HOV lanes during the mid-day period compared to peak period use.

The survey revealed the existence of HOV lanes likely did influence respondents' decisions to share rides: 15-18%[1] of current HOV users would probably switch to driving alone if the HOV lanes were "not available."[2]

[1]This 15-18% figure is an unweighted average of responses collected during three time periods of the day (morning peak, mid-day, and afternoon peak).

Selected HOV User Survey Responses, 2006

	Carpool Riders	Vanpool Riders	Transit Riders
If HOV Lanes were not available, what is the thing you would most likely do?			
Continue to travel the same way	39%	66%	68%
Switch to driving alone	18%	15%	17%
Switch to driving on a different route	19%	4%	3%
Switch to different hours of travel	7%	4%	2%
Switch to transit	5%	2%	n/a
What are the top three reasons you utilize a shared-ride mode?			
Travel time	78%	54%	37%
Convenience	66%	41%	51%
Less stressful	43%	56%	63%
Save money	41%	85%	81%
Environmental impacts	18%	27%	27%

Source: WSDOT, Urban Planning Office

Note: These responses are a combination of responses given for HOV lane users for three different time periods through the day (morning peak, mid-day, and afternoon peak). They are not weighted. These answers represent the top five most common answers to the two questions. A full report with all responses will be available at http://www.wsdot.wa.gov/hov by the end of the year.

About two thirds of carpools (67% of peak period carpools, and 72% of mid-day carpools) are made up of people from the same household. Household carpools would be more likely to drive alone than non-household carpools if the HOV lanes were not available.

Upwards of 85% of bus riders and vanpoolers, and 25% of carpoolers, use employer rideshare incentives.

Although HOV lanes are primarily used for work commuting during the peaks, people also use the lanes for running errands, getting to appointments, and other daily activities. These non-employment-related uses significantly increase during the mid-day.

A full report on the HOV survey results is expected to be available by the end of the year at http://www.wsdot.wa.gov/hov.

[2]WSDOT feels the 15-18% figure might be low due to the way the question was phrased. The question, "If HOV Lanes were not available, what is the thing that you would be most likely to do?", did not differentiate between a short-term or long-term/permanent unavailability of the lanes. Based on other national surveys, it is believed that a higher percentage of shared ride users might switch back to a single-occupant vehicle if the HOV lanes were closed permanently.

Case Study Projects: Minimizing Construction Impacts on Safety and Congestion

I-90 Downtown Spokane Viaduct Bridge Deck

Heavy traffic volumes and high studded tire use caused severe rutting (1/4" to 2") on the surface of I-90 through downtown Spokane. Traffic volumes on this section of the freeway have doubled since the resurfacing was last done in 1985-86. To provide safe operating conditions for the over 90,000 vehicles a day that travel this section of I-90, the Legislature authorized a bridge deck resurfacing project. Work began in May 2006.

WSDOT Coordinated With the Public and Other Agencies

This project required an extensive public relations effort, detailed coordination with the City of Spokane Engineering and Traffic Departments, and in depth planning with Law Enforcement and Emergency Services. These entities helped to cooperatively establish emergency response plans, detour and alternate routes, and construction signal timing plans for approximately 100 signals in downtown Spokane. WSDOT staff conducted over 50 meetings and presentations with participation by the Spokane Chamber of Commerce and the Downtown Spokane Partnership.

Specific Strategies Used to Mitigate Delay During Construction to Address Potential Congestion

Planning the Construction Site to Decrease Congestion Potential

WSDOT modeled the capacity on I-90 during construction and developed recommendations for ramp closures, speeds, and lane widths during the project. At the same time, WSDOT prepared information fact sheets and presentations to explain the approach to the public and other stakeholders. In addition, the construction phasing was carefully planned and executed by WSDOT and the contractor, resulting in a rapid construction process that finished three weeks ahead of the scheduled completion date.

Developing Alternative Routes Into the City of Spokane

WSDOT used an extensive media campaign to encourage commuters to use alternate routes into the City core, leaving capacity on I-90 in the construction zone for through trips. It was essential that normal daily freeway volumes be reduced during construction to alleviate delays and backups. In fact, during the construction, traffic volume on I-90 reduced by approximately 27,000 vehicle trips a day. In addition, WSDOT and Spokane staff modeled the City of Spokane street network and developed a traffic signal timing plan which better accommodated the modified traffic patterns and shifted volumes. These modifications ensured that ramps that were to remain open during construction did not back up onto the freeway, causing congestion and safety concerns, while still providing adequate circulation in the city core.

Managing traffic in the construction zone

Managing traffic flow through the construction zone was also a critical element of the overall construction traffic management plan. Three Washington State Patrol motorcycle troops enforced traffic speed and quickly responded to collisions and disabled vehicles. WSDOT also coordinated extensively with other emergency services to quickly respond to incidents.

Real-Time Traffic Information

WSDOT also worked with the City of Spokane Traffic Department to install five traffic cameras on critical corridors accessing I-90 along the work zone. These cameras provided real time information about problems that occurred on the city street network, allowing the city to make signal timing and signing adjustment to improve traffic flow.

The Results

All of these efforts to manage traffic during the construction had excellent results. No accidents occurred in the work zone, despite reduced lane widths and reduced lane availability (two rather than three lanes each direction). There were no significant delays on I-90, and the city street network remained operational.

Phase Two of this project will begin May 14, 2007. There will be no substantial changes from the approach used in Phase 1. The project is currently on schedule and in budget.

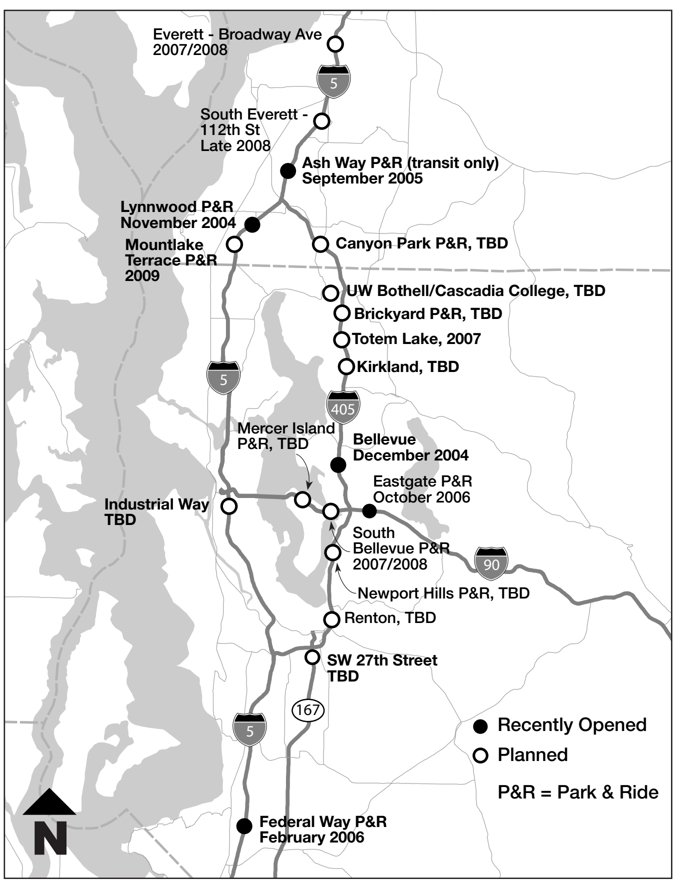
Case Study Projects: HOV Direct Access Ramps

HOV Lane Direct Access Ramps: Five Completed, 14 More are Planned

WSDOT is building many HOV lane direct access ramps throughout the Puget Sound area for Sound Transit. Direct access ramps allow buses, carpools and vanpools to directly access the high occupancy vehicle (HOV) lanes from park and ride lots and local streets. When carpools, vanpools and buses connect directly with HOV lanes, these vehicles no longer have to weave across the general-purpose lanes. Direct access ramps improve safety, reduce congestion, save time, and increase reliability for both HOVs and general-purpose traffic.

Five major HOV lane direct access ramps in the Puget Sound area opened recently. Fourteen more direct access ramps are planned. The map below shows where WSDOT is implementing direct access projects.

HOV Direct Access Ramps in the Central Puget Sound Region, Current and Planned



Preliminary performance evaluations have been completed for the Lynnwood, Bellevue, Federal Way, and Ash Way projects. Substantial travel time savings have been achieved at both Lynnwood (four to eight minute savings) and Ash Way (two to six minutes), resulting in revised, improved Sound Transit and Community Transit bus schedules. At the Bellevue Downtown ramp, only modest time savings of between one and two minutes for each bus route have so far been achieved. However, in Bellevue, as many as 83 buses in each peak period are no longer required to weave across I-405's general purpose lanes. Preliminary time savings data is not yet available for the Federal Way S. 317th St. access ramp and the Eastgate Transit 142nd Pl SE access ramp, both of which have been opened within the past year. The table below lists each ramp's transit and total daily volumes and time savings.

Direct Access Ramps Vehicle Volume and Time Savings for HOV Users After Implementation

Direct Access Ramp Location	Transit Daily Volume	Total Daily Volume	Time Savings
Lynnwood	212	4100	4-8 minutes
Bellevue	292	3700	1-2 minutes
Ash Way[1]	127	200	2-6 minutes
Federal Way	233	5600	n/a

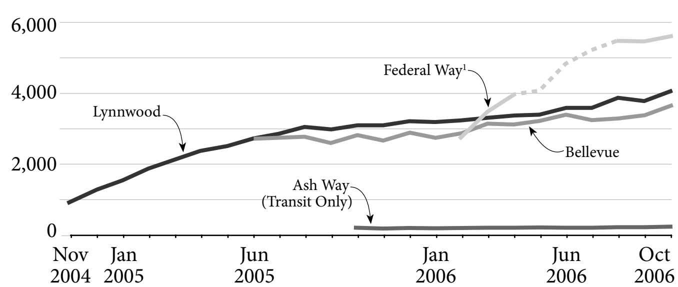
Source: TRAC and WSDOT Northwest Region Office

[1]The Ash Way Direct Access Ramp is for transit (buses) only.

The graph below shows the rapid growth of the use of direct access ramps upon their opening. Currently, the Lynnwood and Bellevue direct access ramps carry nearly 4,000 vehicles per day each and the Federal Way ramps lead with over 5,600 vehicles per day. The Ash Way ramps, which are restricted to transit vehicles, carry approximately 200 vehicles per day.

Direct Access Ramp Volumes

November 2004 - October 2006



Source: WSDOT, Northwest Region

[1]From May 2006 to September 2006, WSDOT did not have data for one of the four direct access ramp lanes in Federal Way due to a bad loop detector. During that time, WSDOT interpolated the fourth ramp's volume based on previous data from when the loop detector there was working. The line is dashed for that period since it shows estimated and not actual data.

Measuring Delay and Congestion: Annual Update

Understanding the Relationship Between Congestion and Safety

Is there a correlation between highway congestion and traffic collisions? WSDOT plotted fatal and disabling collisions for the entire length of I-5 by hour on the graph below, then added congestion data by time of day (in the black areas).

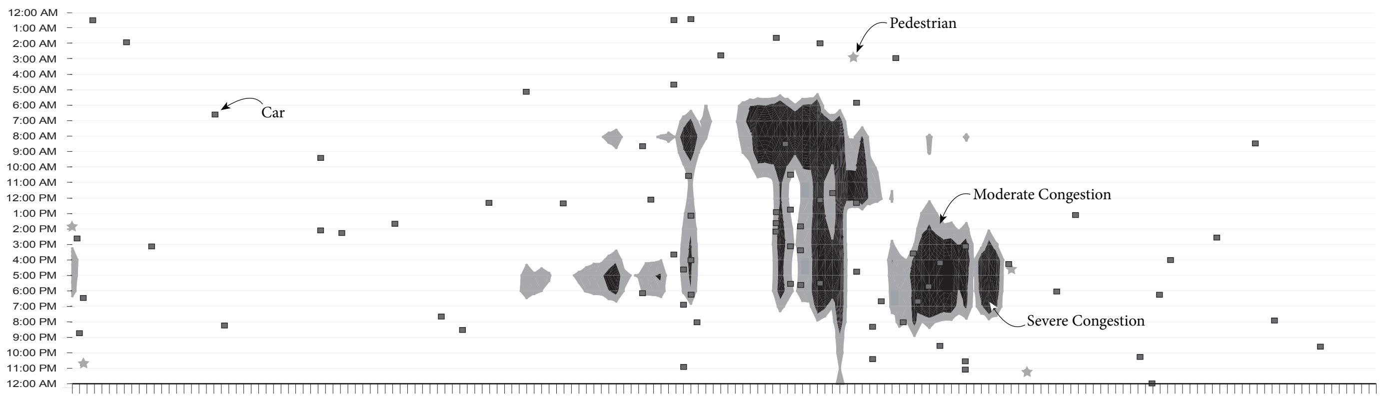
Fatal and Disabling Collisions and Congestion
Based on this sample data, congestion does not appear to be a major factor in serious collisions. Further analysis is warranted.

Rear-End Collisions and Congestion
Rear-end collisions on the other hand correlate with congestion. There appears to be a definite link between rear-end collisions and congestion. For more information on highway safety, see pp. 82-85.

WSDOT will continue to study available data in order to determine congestion and traffic collision relationships and their implications.

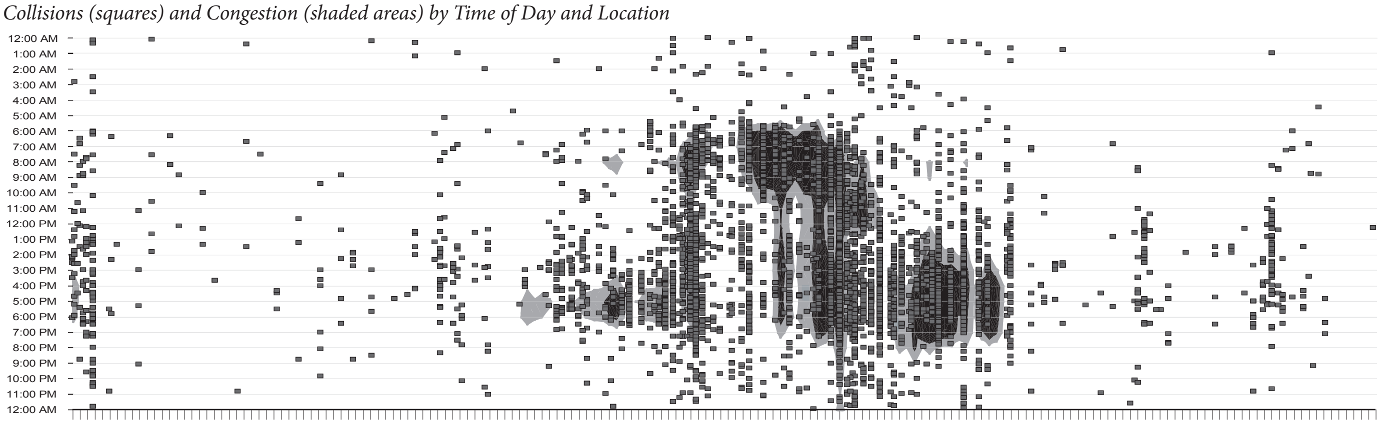
Northbound Interstate 5: 2005 Fatal and Disabling Collisions and Congestion Occurances

Collisions (squares and stars) and Congestion (shaded areas) by Time of Day and Location

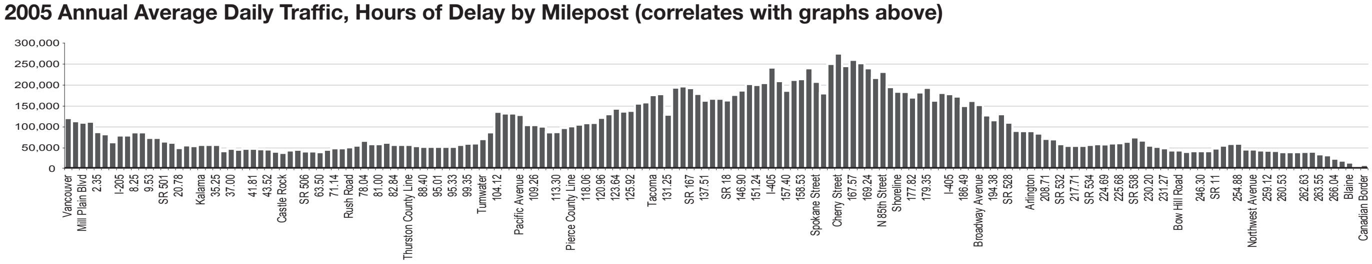


Northbound Interstate 5: 2005 Rear End Collisions and Congestion Occurances

Collisions (squares) and Congestion (shaded areas) by Time of Day and Location



2005 Annual Average Daily Traffic, Hours of Delay by Milepost (correlates with graphs above)



Estimated 2005 General Purpose Lane Performance

* Federal Law Title 23 U.S. Code Section 409 prohibits the discovery or admission into evidence of this data in Federal or State Court proceedings or consideration in any action for damages.

Measuring Delay and Congestion: Annual Update

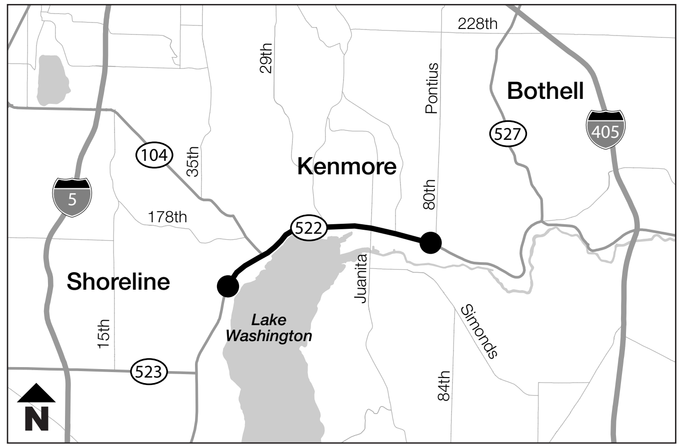
Traffic Data Collection for Arterial Highways

WSDOT has a well-established data-collection system on major Central Puget Sound region highways. This system gathers historical travel time, delay, and traffic volume information, along with real-time traffic data for travelers. Much of the data is collected from magnetic "loop detectors" embedded in the pavement. Unfortunately, similar travel time data is not collected by WSDOT for the arterial highways, which are equally crucial elements of the state highway system. Data for the arterial system could be used for real-time travel information on WSDOT's web traffic flow map, real-time traffic management, and highway performance reporting.

New Technology Can Provide Arterial Data

In response to operational issues in gathering data on the arterial system, WSDOT is currently piloting a test of Automated License Plate Recognition (ALPR) technology. (See the gray box to the right for more information on ALPR). ALPR provides WSDOT with low-cost, flexible data collection on arterial highways as well as freeway segments that do not yet have loops. For instance, ALPR could be installed on mountain passes to provide winter travelers real-time information.

Based on this initial pilot test, WSDOT is developing a plan to install the system on other critical freeway and highway segments. The expansion of this program is not fully funded at this time, but candidate routes include SR 9, SR 18, SR 99, US 2, and I-5 north of Everett. An additional benefit of the ALPR data collection is the ability to gather performance data on arterials improved by Nickel and TPA projects.



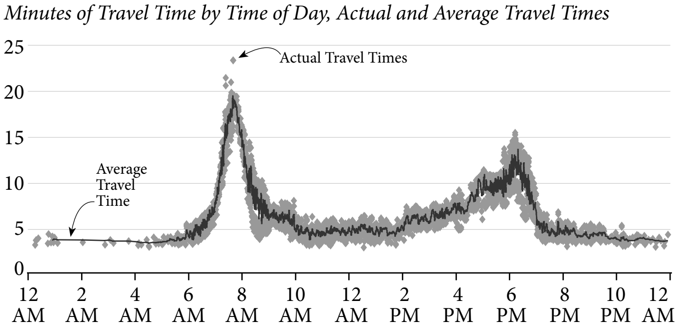
How Does ALPR Technology Address Data-Gathering Problems on Arterial Highways?

Arterial highways are roadways with traffic signals which carry large volumes of traffic in and between urban areas that include access to local development. Arterials pose a unique challenge for loop detectors: traffic signals and closely-spaced access points interrupt traffic flow along an arterial corridor, making it very difficult for loops to measure travel time as they do for the freeway system. WSDOT's current approach for measuring arterial highway performance is to conduct "floating car" studies, in which engineers drive the corridor and capture the time it takes to get from one point to another. This method is time-consuming and provides a very limited measurement of how the arterial highway is performing.

Automated License Plate Recognition (ALPR) is used for reading license plates, primarily for security purposes. The technology uses a pixel recognition program to convert a snapshot image of a license plate to text. (Data is discarded after the system gathers the needed travel time data.) In this instance, ALPR is being used to collect real-time travel data on routes despite the constant interruption of traffic flow that foil data-gathering by loops. In WSDOT's test, each pixilated license plate image is automatically converted to a unique time-stamped code to maintain privacy; this is the only information retained. The time-stamps of an image captured at multiple locations can then be converted to a travel time for the arterial road.

The initial test of this system is being conducted on SR 522 between NE 170th and 80th Ave (see the map above). It has been active since October 2006 and has provided continuous and useful travel time information along this two-mile highway segment (see the graph to the left).

SR 522 (Westbound) Travel Times, October 2006
80th St. to 170th Ave., 2.37 miles
Minutes of Travel Time by Time of Day, Actual and Average Travel Times



Source: WSDOT, Northwest Region